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# **Vision Northwest**

#### ABSTRACT

Unilateral Spatial Inattention is sometimes challenging to differentiate from true hemianopsia. Visual field testing can appear to be variable and inconsistent. The results of field testing may be conflicting depending on the method used. Factors to consider are static versus dynamic targets, dual presentation, differences in target size, and other variables demanding increased attention. It is also important to examine the multi-sensory influence on the performance of the patient based on the neural pathways being utilized in each task. The following is a discussion of evaluation techniques of visual fields in patients who have suffered an acquired brain injury. Further, there will be a case example of an individual diagnosed with a right MCA stroke and secondary visual field defect who presented with unique visual field results. Knowledge gained from comparison of these procedures may affect treatment. An example would be a patient with no USI while sitting, but finding USI when asked to stand. This individual may demonstrate visual field difficulties when attending to anything involving movement and balance. This unique aspect of processing of vision from a multi-sensory model can make treatment for such individuals more efficient, well defined, and effective. This information will be essential for multi-disciplinary interactions to create better treatment strategies among rehabilitation disciplines. The procedures to be evaluated will be confrontation fields, static automated perimetry, and tangent screen field under varied circumstances and test conditions to optimize treatment and maximize performance of activities of daily living.

#### BACKGROUND

The primary visual cortex, V1, is responsible for magno-cellular and parvo-cellular pathways, on/off receptive fields, directional orientation. ocular dominance and directional dominance 1. When information goes to V1 it divides into the ventral and dorsal sub pathways. The dorsal pathway sends information to V2, which then goes to either V3 (DM) 2 or V5 (MT). This pathway is responsible for motion detection, representation of object locations, and control of hand/eye coordination. The ventral pathway sends information to V2, which then sends its fibers to either V4 or the inferior-temporal cortex. The ventral cortex is responsible for form recognition, object representation, and long term memory. If the primary visual pathway is damaged further down the pathway past V1, the specific brain area affected determines the functions affected 3. The functions of these areas are as follows:

V2: orientation, spatial frequency, color, orientation of illusory contours, binocular disparity, visual figure ground. V3 (DM): orientation of visual contours, low spatial frequency, motion of self

V4: orientation, spatial frequency, color of intermediate complexity V5 (MT): fast motion, and likely form by motion

inferior-temporal cortex: face recognition, global space 4

If any of these are disturbed, then these functions would be disrupted; however, there are a few exceptions. The secondary visual pathways are composed of visual fibers that go to the pre-tectal nucleus instead of the lateral geniculate nucleus. These fibers then feed into the Edinger-Wesphal nucleus and send connections to the frontal eye fields 5. There is also the Riddoch phenomenon. This phenomenon involves individuals with complete hemianopsia in their blind field. It occurs while detecting an object that is kinetic in nature but not able to detect an object of static nature 6. Studies using fMRI have shown that this is from direct activation of V5, V3, and the parietal cortex 7.

#### PICTURE 1: A DIAGRAM OF THE VISUAL PATHWAYS



AROUSAL  $\rightarrow$  ATTENTION  $\rightarrow$ MEMORY  $\rightarrow$  LANGUAGE  $\rightarrow$ PRAXIS  $\rightarrow$  RECOGNITION -> VISUAL-SPATIAL **RECOGNITION →** COMPLEX COGNITION

In the case of unilateral spatial inattention, it is not an issue with V1. Instead, it is an issue with attention. Attention is "the entire family of processes that mediate the choice of suitable mental or external events for consciousness and action" 8. Attention lies along a continuum of consciousness, as follows:

arousal --> attention --> memory --> language --> praxis --> recognition --> visual-spatial recognition --> complex cognition. Bottom-up impairment would include issues with arousal and attention, which have a negative effect on the rest of the series 8. Therefore, any damage to attention will also affect visual-spatial recognition, defined as "abilities involving visual processing skills, spatial awareness, self-object spatial relationships, visual spatial memory and navigation of extra personal space" 8. A disturbance in this spectrum would cause unilateral spatial inattention.

Understanding what areas of the brain control attention is unclear. It is well accepted that USI is primarily a dysfunction of the parietal lobe with issues also found from lesions in the cingulate gyrus, frontal eye fields, and brain stem 9. Interestingly, the left parietal lobe controls only attention to the right side of the body while the right parietal lobe controls attention to both sides of the body. Experimentation of those with parietal lobe damage has shown that the process of engaging one object, releasing attention and shifting to another object is controlled in the parietal lobe and damage to this area causes neglect 10. Agreement across neuropsychology demonstrates that cortico-subcortical frontoparietal connections control spatial attention and damage to these areas would cause hemi-neglect in the contra-lateral field 11. However, a study by Benson, et. al. has shown this may not be the case. In a single case experiment with control, it was determined that USI was an imbalance in saccadic orienting as well as a combination of inability to perceive information visually sampled and hyper-attention in the normal field 12. If an individual sustains an acquired brain injury, basic anatomy

is crucial to understand how this affects the visual field so that it is easier to differentiate USI and true visual deficits. Based on the site of the brain injury, it can be predicted what the visual outcome would be. A cerebral vascular accident would affect vision as follows13:

TABLE 1: LOCATION OF CEREBRAL VASCULAR FIELD OR ATTENTION DEFECTS	R ACCIDENTS IN THE BRAIN AND RESULTING VISUAL
Site of Cerebral Vascular Accident	Affect on Function
Anterior Cerebral Artery	USI, junctional defect, sector defect
Middle Cerebral Artery	USI, superior or inferior quadrapsia, incomplete hemianpsia
Posterior Cerebral Artery	Hemianopsia, inferior quadranopsia
Thalamus	USI
Midbrain	USI, ambient pathways

#### **EXAMINATION OF VISUAL FIELD TESTING**

There are many ways in which an individual's visual field can be tested, including confrontation, tangent screen, and automated perimetry. First, there are variables in target. In confrontations, one can use counting fingers, finger motion, or a confrontation wand. Variation in color is also used, commonly white or red targets. Counting fingers requires form recognition. Finger motion and confrontation wand is kinetic and incorporates motion detection, which could bypass V1 and be detected directly by MT. This can be the case if the person is counting fingers if there is motion in presentation. In general, confrontation fields are completely unreliable for small defects and only find well defined large defects 14, 15. Confrontation testing only seems to detect a defect about 38-50% of the time if it is not a defined defect such as altitudinal defect or homonymous hemianopsia 15, 16. Regardless of this fact, it is still commonly used in vision care regularly as a visual field screener. Because it does pick up large defects, such as hemianopsia and quadranopsia, it is perfectly acceptable as an initial test to identify a substantial loss 17. This makes this test a quick, easy test of ABI patients and in visual neglect.

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It has been sighted that automated perimetry is more accurate in diagnosing neurological disease than kinetic perimetry, making static Humphrey perimetry the standard of care. Humphrey specifically is more accurate than Matrix or FDT due to the fact that it is a solid flash of light as opposed to a frequency doubling image, which can induce a motion effect. It is more accurate because it will not activate MT by bypassing V1 18. However, it is not as accurate in giving a true localization of the defect in the brain based on the field detected. Humphrey visual field is more likely to show a more severe defect than is truly present compared to tangent screen fields and Goldman Perimetry 19. Advantages are the precise repeatability of this testing method and the decrease in testing time. It also has the advantage of removing cues like a tangent rod 20.

There are several issues with using the above mentioned tests when dealing with determination of a unilateral spatial inattention vs. hemianopsia. Each element of discord is in relation to changes to attention based on position of the individual, the task they are asked to perform, proprioceptive influences on performance, and various inter-related neurological issues. First, there is the question of the accuracy of the above mentioned tests due to posture. If the patient is sitting, this is not a true gauge of how this person will perform during activities of daily living or when ambulatory in physical / occupational therapy. When an individual stands, they must attend to balance and cognitive abilities must now be split between visual awareness and balance. Since balance is tightly intertwined with peripheral vision, it is harder for someone to attend to visual stimuli when using vision for balance, making USI more pronounced. A study on the effects of a cell phone conversation on visual field using Goldmann Visual fields demonstrates this well. They tested normal individuals with and without visual complaints and compared their visual field to one performed while on a cell phone. There was a significant decrease in visual field when attending to a phone conversation 21. When this idea is translated to visual field testing, it would be advantageous to have the patient both sit and stand while being tested for confrontation visual fields. During USI, one is likely to show differences, while with a hemianopsia, the loss would be constant. However, some patients may have visual field loss coupled with USI, making diagnosis difficult.

Another aspect that needs to be considered is the MIB effect (motion induced blindness). MIB causes extinction of a peripherally viewed object when focused on a central target when these peripheral targets are flashed to make apparent motion. The suppression of micro saccades changes the gain in the visual system and causes disappearance of the peripheral targets. A study by A. Gorea and F. Caetta 22 showed that this extinction of peripheral objects is not isolated to the MIB effect alone. In their experiment, they also used static mask and absent mask targets to test the extinction phenomena and how it varied under these three conditions. They found that, although the MIB is a much stronger extinction of the peripheral object(s) being viewed, that there was also temporary suppression found in the other two conditions. These conditions would mimic an automated visual field because of the extent in which the patient has to hyper-focus on a central fixation target. This may be why the extent of visual field severity is usually more pronounced in automated static perimetry than in tangent screen fields.

There are also variations that can be made in proprioception that can be positive in the detection of visual fields. According to Riddoch and Humphreys 23, there is a distinction between extinction and unilateral spatial inattention. This distinction is important to understand, as this would change the results of testing. Often, these are considered one and the same. If a patient is presented binlateral targets and one is extinguished consistently on the left side, this is labeled left neglect (USI). However, when presented a single target on the same side as visual extinction, they may actually see the target. Also, with USI, there does not have to be competing stimuli for the individual to not see the stimulus presented in the neglected field. The difference is in the attending ability of the brain and possible different 'anatomical substrates' 23. In visual extinction, the patient may or may not attend to an object based on the circumstance in which it is presented. They found that in patients with a brain lesion, if presented objects oriented for action, the patient always saw the active object instead of the passive object regardless of location in space. However, if the same pictures were presented without showing action toward each other, the patient would pick up the picture on the ipsi-lateral side. When presented two objects that are the same, they did not consistently extinguish the object on the contra-lateral side. An example was presentation of handled cups. If the handle was turned to the left (contra-lesional side), the patient was much more likely to attend to the object because it engaged motor planning on the left side. They also found that motor planning that required attention to the ipsi-lesional side and then disengagement to attend to the contra-lesional side showed performance benefit 23. This is the complete opposite of USI, which has difficulty disengaging attention from the ipsi-lesional side 10.

Patients with USI sometimes show signs of varied symptoms based on whether the targets are in peri-personal space or extra-personal space. Patients who perform tests in peri-personal space can show neglect while having normal responses in extra-personal space. However, when the person wields a tool, this makes that extra-personal space become part of the peri-personal space schema. This evidence shows that neglect may not just be attention but an alteration of body schema 24, 25. Maravita and colleagues suspect that wielding of tools relates to properties of intra-parietal neurons 25. Considering that neglect comes from damage in the parietal lobe, this would coincide with the idea that if something is in the peri-personal space, it requires use of the parietal lobe and would exhibit neglect; however, outside this area would not be using damaged areas of the brain. Based on these ideas, treatment can then be manipulated to work on correcting body schema to increase awareness on the neglected side.

#### TABLE 2: COMPARISON OF VISUAL FIELD TESTING

Field Type	Positives	Negatives
Confrontation	Quick & Easy Picks up large defects (good for USI and hemianopsia) Can test static and kinetic	Does not detect small defects Background can affect testing (color of shirt, room)
Tangent Screen	Sensitive to small defects Accurate for brain localization	Time Only kinetic Cues (arm, wand)
Automated Perimetry	Static Picks up small defects Computer analysis comparison to age normal	Can have tunneling (MIB effect) Kinetic programs not very good Poor accuracy in brain localization Defects are greater than they may actually be

One method used to alter this body schema is neck vibration. Neck muscle vibrations stimulate alpha motor neurons, creating an illusion of head-on-trunk rotation to the side of the vibrations. This works by tricking the brain into thinking that the vibrations are lengthening or shortening the muscles 24. Karnath and colleagues have demonstrated this to be an effective treatment. They have also tested if this effect would work with other areas of the body (i.e. left hand, head) but this did not have any effect 24, 26. These results were confirmed with later studies 27. Rotation of the trunk 15 degrees to the left also showed improvement 27. This changes egocentricity, correcting the neglect by altering the egocentric coordinate system used in 'visuomotor coordination and exploration of space' 27. This is the same principle commonly used in prism adaptation treatments 24. However, Roeden and colleagues found that neck vibration was not valuable in affecting visuo-spatial attention 24.

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Another tool for improving neglect is with vestibular input. Karnath31 found that spatial neglect and vestibular processing at a cortical level involve common brain areas. Functional imaging studies have revealed the superior temporal cortex, the insulate and the temporoparietal junction to be important components of the multi-sensory system affected by neglect. With this in mind, we have also applied vestibular input to our patients' therapy programs. Karnath 32 found that by using caloric vestibular stimulation he was able to improve the neglect. We have found similar improvements in our patients with rotational vestibular stimulation. The patient is rotated 5-10X to the left on a computer chair or wheelchair. This provides a post rotary nystagmus to the left and an increase in attention to the left visual space.

We have found patients have responded best by using cervical and/or vestibular input followed immediately by increased spatial awareness activities, especially tasks that are multisensory and bi-hemispheric in nature. An example would be using a pencil and drawing a clock with appropriate numbers in order. The patient is required to recall the number sequences (left hemisphere function) with the spatial distribution on the clock (right hemisphere function). For example see Picture 2, which shows a typical left neglect response with the numbers primarily on the right side from a patient who suffered a right middle cerebral artery stroke. When the patient is asked to draw the numbers in reverse order from 12 to 1, he has then shifted well to the left side because he is unable to alternate his attention between right and left hemispheres 28. In this case of right hemisphere brain damage, the patient dominantly attends with the left hemisphere. The patient cannot attend alternately to both spatial awareness (right hemisphere) and sequencing (left hemisphere). As recovery improves, the patient is able to increase right hemispheric processing (spatial distribution of numbers) and draws the clock better. Rotational vestibular, cervical and bi-hemispheric activities need further investigation via formal study.

#### DISCUSSION

Taking the above mentioned principles into account, this alters the way one would view the application of visual fields in the diagnosis and treatment of those with a suspected USI vs. hemianopsia as well as influence the treatment. This is explained in the table below:

TABLE	3:	RESULTS	0	F	C	ION	IFRC	<b>NTA</b>	TION	VISUAL	FIELD	IN
VARIOUS	s Co	<b>NDITIONS</b>										
0 1			0	C				A			NT 1	

Condition		Neck			
	Static	Motion	Dual Pre	Vibration/	
			Static	Motion	Vestibular Input
Normal	Normal	Normal	Normal	Normal	Normal
Hemianopsia	Abnormal	Normal*or	Abnormal	Normal*	No change
		Abnormal		or	
				Abnormal	
USI	Abnormal	Abnormal	Abnormal	Abnormal	Improved
Extinction *Riddoch phenomer	Normal	Normal	Abnormal	Abnormal	Improved

The easiest means to diagnose an individual with ABI for these conditions is using confrontation visual fields with a vibration device. This is easy, requires no equipment that can't be easily transferred, and therefore hospital friendly.

#### CASE TL

This patient is an 80 year old female who suffered an MCA CVA in the M2 branch in July 2012 and was given tPA to improve her outcomes. This patient was unaware of her neglect. She has been tested for simultagnosia, which was negative. After receiving therapy, she was cleared in March 2013 by the driving Rehabilitative Services for driving and the examiner (an occupational therapist) noted no signs of left neglect. Below is a review of her progress and the therapies she performed. Treatment at our office began in October 2012.

As exemplified in the case given, a patient may show neglect initially in a static and kinetic presentation. However, as attention improves, kinetic fields generally improve before static fields. Since real-world situations are rarely static, it suggests she would be safe to drive because all targets would be either moving or have a motion parallax effect when in a moving vehicle. Therefore, Humphrey visual fields don't truly tell us how this patient is functioning. It is important, however, to have these patients examined by an occupational therapist for driving rehabilitative services because they investigate additional aspects of these tasks that are beyond our scope of practice.



PICTURE 2: CASE TL A) LEFT STATIC FIELD; **B) NEGATIVE FOR** SIMULTAGNOSIA; C) DUAL PRESENTATION; D) TWO-HAND BEAN BAG TOSS THERAPY

**PICTURES USED WITH** WRITTEN CONSENT BY THE PATIENT.



TABLE 4: CASE TL- PROGRESSION OF RESULTS OVER TIME						
Visit	Static Confrontat ion Finger Counting	Kinetic Confrontation Finger Counting	Dual Presentation	Full Threshold Visual Field (Humphrey)		
eptember 2012				OD & OS complete left hemianopsia with enlarged blind spot and decreased detection in the right field.		
October 2012	Left defect	Normal	<ul> <li>left extinction (static &amp; motion Count fingers)</li> <li>no improvement with cervical stimulation</li> <li>Then, had patient hold out own hands and be aware of them—she sees them both. self-present dual targets : no extinction no effect with neck vibration</li> </ul>	Incongruous left hemianopsia		
December 2012				OD: left hemianopsia OS: left inferior quadranopsia		
February 2013	Left defect	Normal	Left extinction (static & motion Count fingers) Had patient throw beanbags up in each hand simultaneously. Post- Beanbag: No extinction Added turn-and-clap therapy	OD: Left incomplete hemianopsia OS: Left inferior quadranopsia		
March 2013	Left neglect	Normal	Left extinction (static count fingers) Static R target/Kinetic left target, count fingers: no extinction			

### **PICTURE 3: HUMPHREY VISUAL FIELDS FOR CASE TL: COMPARISON OF DECEMBER TO FEBRUARY**



## **PICTURE 4: COMPARISON OF DRAW-A-CLOCK TEST WHEN STARTING CLOCKWISE VS. COUNTERCLOCKWISE.**

These are from the same patient, Massive R ICH secondary to HTN (X 10yr). This is not patient TL.



## CONCLUSION

Testing of visual fields and USI can be done by confrontation, tangent screen, and threshold testing. This can be used with imaging to develop a good understanding of the type of loss (i.e. hemianopsia/ quadranopsia verse USI or combined defects). Each test has different demands that need to be shared with the multidisciplinary team. An important consideration is testing for USI while standing vs. sitting.

Confrontation fields counting dingers should include both static and kinetic presentation. Testing can also include variable probes including: (A) standing vs. sitting, (B) cervical stimulation, (C) vestibular stimulation, (D)peri-personal vs. extra-personal space.

The use of the above probes, integrated with traditional USI therapy, should help speed the recovery and overall outcomes of USI. The use of these probes with the multidisciplinary team may provide both a safer process of rehabilitation and treatment that is more efficacious to improving a variety of different activities of daily living.